In this first phase, the switcher need only be of relatively simple design, to be expanded in later phases.

A station ID is inserted at this point. The signal is then encoded and fed through the STL to the transmitter and antenna.

Phase B: - Local Commercial Insertion

Two VTRs for the playback of HD commercials are added, feeding an automation switcher. When only NTSC commercials are available, an up-converter may be installed, increasing the 525 lines of NTSC.

Phase C: - Local Playback of Non-Network Programs

Requires the addition of program VTR's and a routing switcher.

Phase D: - Local Origination

Requires the addition of studio cameras, VTRs, and a production switcher.

Phase E: - Final Plant Conversion

Calls for the addition of a down-converter in order to feed HD programs to the NTSC transmitter for simulcast operations. An HD cart machine for the playback of commercials is added in this phase, together with test and monitoring facilities.

Phase F: - ENG

Requires the addition of HD camcorders, VCRs, and editing facilities. Existing microwave links will be used.

5. FINANCIAL ASSUMPTIONS

In assessing the costs of implementing each phase of the conversion to HDTV, the following financial assumptions have been made.

5.1. Labor

The cost estimates include the labor for installation. For broadcasters who capitalize labor for installation, the labor cost for the type of equipment and systems considered is assumed to be 20 percent of the capital equipment cost.

Some stations will use in-house technical labor for installation, while others will employ outside contractors. The amount of labor required for installation will vary widely with the physical conditions and equipment existing at individual stations. Accounting procedures for recording labor costs also vary from station to station. Overall, however, a 20 per cent factor for labor is believed reasonable.

5.2. Transmission Signal Format

A number of HDTV proponents have proposed systems using lower power transmitters and lower ERP than NTSC. The transmitter power could be 10-20 dB less than a current NTSC transmitter to provide similar coverage.

For example, a typical NTSC UHF transmitter has an ERP of 1 megawatt, while a HDTV transmitter would have an ERP ten to one hundred times less. Such reductions in power also lead directly to reduced costs for primary power.

This is important because the HDTV system adopted for terrestrial transmission must allow the simulcast transmitter to be located approximately 100 miles from a co-channel NTSC television station without causing interference, while providing HDTV service to a comparable area.

The resultant smaller antennas and transmission lines will reduce the weight required to be mounted on the tower. Even more important, the smaller antennas reduce the wind load that a tower must support.

By minimizing the incremental loading, the need for tower modifications, or for an additional tower, is eliminated, and substantial cost savings are achievable.

For purposes of the following analysis, it is assumed that stations will not require a new tower in order to add a simulcast HDTV antenna. This assumption is discussed in Appendix A.

5.3. Economies of Scale

It is assumed that with each doubling of the number of units of equipment ordered annually for HDTV broadcasting, the cost and price of equipment will be reduced by 10% of the prior cost, as equipment design is refined and manufacturing productivity is improved.

Much of the equipment required for conversion is new and initial prices are those currently quoted for prototype and pre-production samples. It is anticipated that prices for production runs of equipment even for the first stations to convert may well be lower than those assumed here.

Moreover, some equipment involved in the conversion process will be sold in many other markets, including program production and post production, medical, printing and publishing, corporate training and communication, and non-broadcast video communication. Such non-broadcast applications will involve equipment quantities far exceeding broadcast needs, and in the future lead to significant economies of scale.

Finally, much of the equipment employed for HDTV broadcasting will be the same or similar to that employed in other countries introducing HDTV service.

Although manufacturers frequently gain market entry by pricing early production units at cost or less, no such assumptions have been made herein, and the prices of equipment used for the conversion of the first 30 stations are, as noted above, the currently quoted prices, often for prototype equipment.

As a result of these considerations, a 10 percent reduction in equipment cost for each doubling of the number of units used for HDTV broadcasting is considered a reasonable, although moderately aggressive, assumption.

5.4. Reuse of Existing Equipment

Existing plant, studio and control room audio equipment will be reused, not replaced. Since all proponent systems include multi-channel digital audio, stereo conversion of local origination is assumed prior to HDTV conversion.

Studio lighting and sets are assumed to require little or no modification. Existing studio/control room/plant communication systems will be reused, not replaced.

6. CAPITAL COSTS

Figure 4 presents the anticipated costs for each phase of the conversion for each of the first 30 stations, (Group 1),

the next 40 stations, (Group 2)

the next 80 stations, (Group 3)

the next 160 stations, (Group 4)

the next 320 stations, (Group 5), and

the next 640 stations, (Group 6), for a total of 1270 stations.

The capital investment in HD equipment for each of the first 30 stations in Group 1 is projected to be $11.6 million. This cost becomes progressively smaller for stations in each subsequent group. Thus, for stations in Group 5, the cost is $7.6 million.

The estimated cost of converting ENG operations to high definition is not shown. HD ENG equipment with the light weight and small size of current professional camcorders is not yet developed, and cost assumptions have not been made. It is anticipated that such equipment will be available in quantity, at a reasonable incremental cost over replacement NTSC equipment, in the time frames envisioned, although it will also prove feasible to defer that investment for several years.

It may well be that, in the interim period prior to the local studio origination and ENG conversion, news and public affairs programs in NTSC will be subjectively improved by electronically artificially increasing the number of lines in the picture prior to transmission. Such "up-conversion" would be a relatively simple operation which would not improve picture definition or color rendition, but would have the subjective benefit of removing line structure in the picture.

SIMULCAST HIGH DEFINITION TERRESTRIAL BROADCAST COSTS BY PHASE AND QUANTITY

$ THOUSANDS*

	GROUPS OF STATIONS ACQUIRING EQUIPMENT					
GROUP	1	2	3	4	5	6
NO. OF STATIONS	30	+40=70	+80=150	+160=310	+320=630	+640=1270
% TVHH SERVED	31	53	83	95	98	100
A - NETWORK PASS-THROUGH	1481	1333	1200	1080	972	875
B - LOCAL COMM. INSERTION	1652	1487	1338	1204	1084	976
C - LOCAL PLAY OF SYNDICATED NON-NET PROGRAMS	1057	951	856	770	693	624
D - LOCAL ORIGINATION	3277	2949	2654	2389	2150	1935
E - FINAL PLANT CONVERSION	4113	3702	3332	2999	2699	2429
TOTAL CAPITAL COST PER STATION	11,580	10,422	9,380	8,442	7,598	6,839

* IN 1990 DOLLARS

FIGURE 4

In Figure 5, the capital equipment cost for Group 1 stations is presented as an annual cost for each year of the conversion process. Referring to Figure 5, the annual capital investment in HD equipment is shown in the upper part of each column, while the lower part represents the continuing, but declining, capital investment in normal (NTSC) equipment.

As the conversion to HD proceeds year-by-year, the investment in NTSC equipment is seen to decline from its historic level of an assumed $1.0 million indicated by the dotted line on the chart.

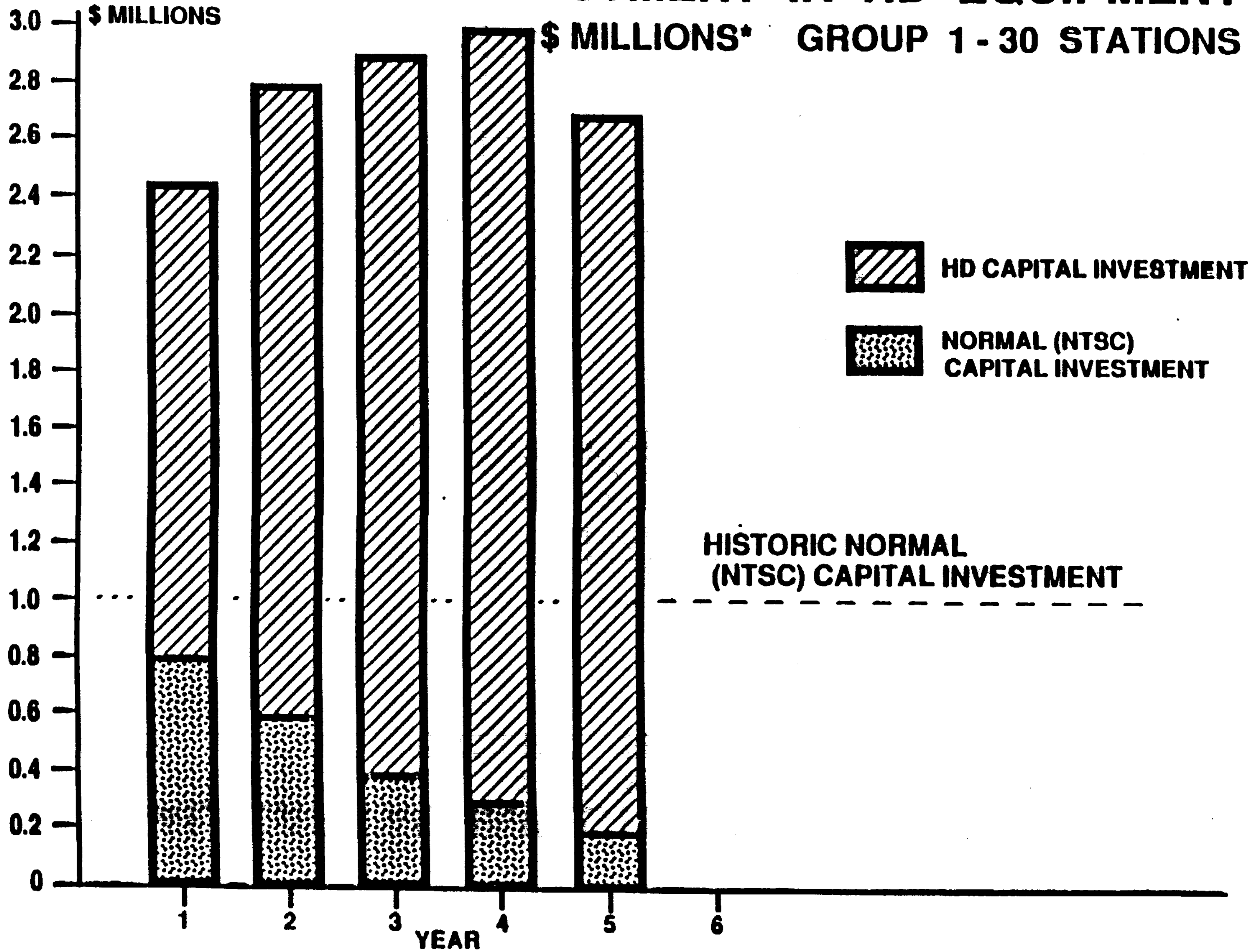
For the 30 stations in Group 1, it is projected that the conversion program can be completed in five years. Similarly, figure 6 shows the annual capital investments for the 40 stations of Group 2. Here the conversion program starts in Year 2 and is completed in six years. Annual investments are lower because the total investment is spread over a longer period than Group 1, and because of lower equipment costs as manufacturing efficiency improves. The total investment in HD equipment is $10.4 million.

Figures 7, 8, and 9 show similar data for successively larger groups of stations (Groups 3, 4, and 5) which start the conversion program in later years and which spread the conversion process over longer periods. Thus in Group 5, the 160 stations involved are assumed to start conversion in Year 5 and to complete the conversion in Year 12, 8 years later (Figure 9).

6.1. Incremental Capital Cost

While the total capital investment in HD equipment is 11.6 million for each station in Group 1, shown in Figure 4, the incremental cost for the five-year period is the sum of the expenditures above the historic normal

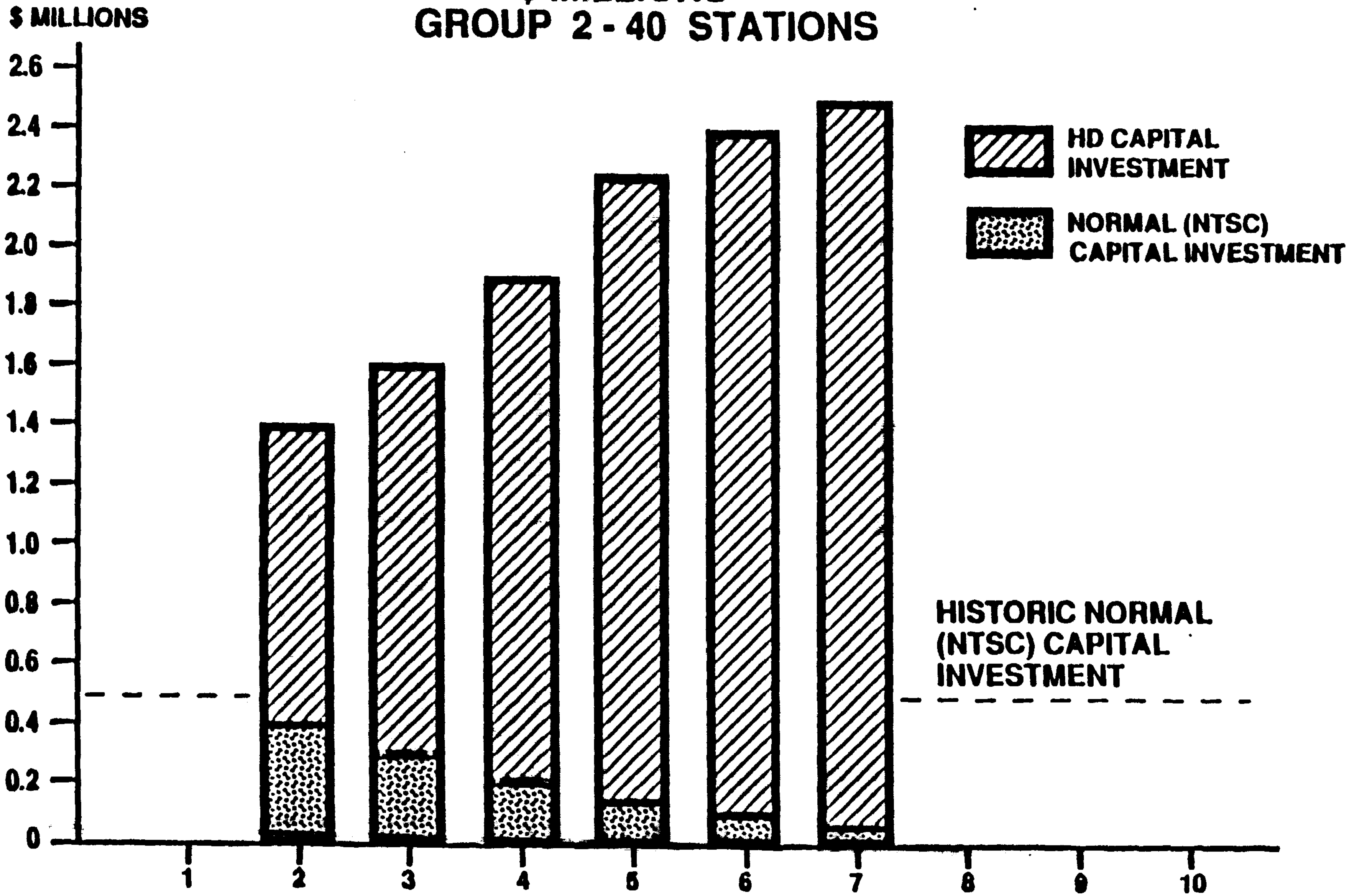
ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT



* IN 1990 DOLLARS

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT

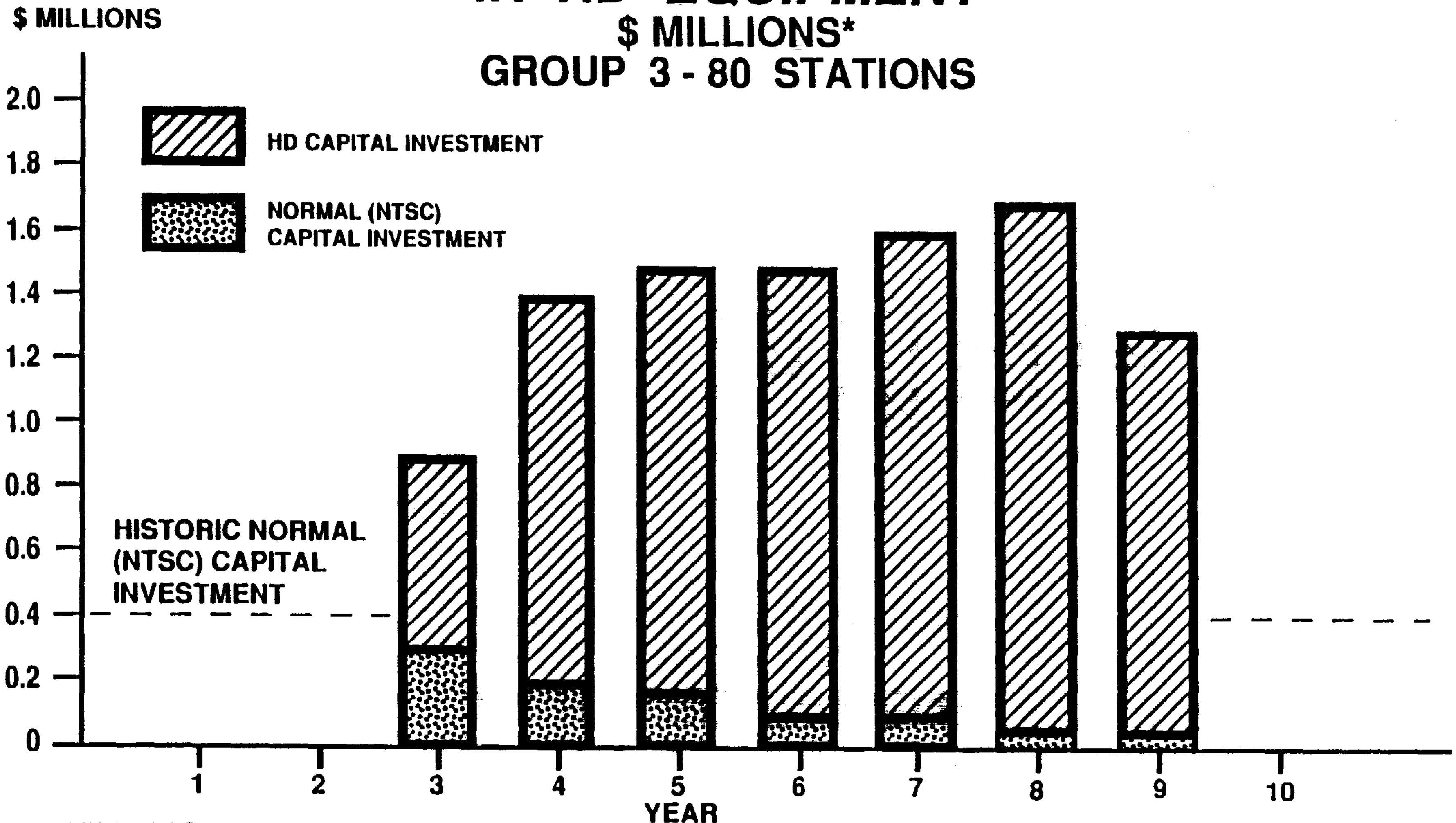
$ MILLIONS*
GROUP 2 - 40 STATIONS



* IN 1990 DOLLARS

FIGURE 8

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT
$ MILLIONS*
GROUP 3 - 80 STATIONS



* IN 1990 DOLLARS

FIGURE 7

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT

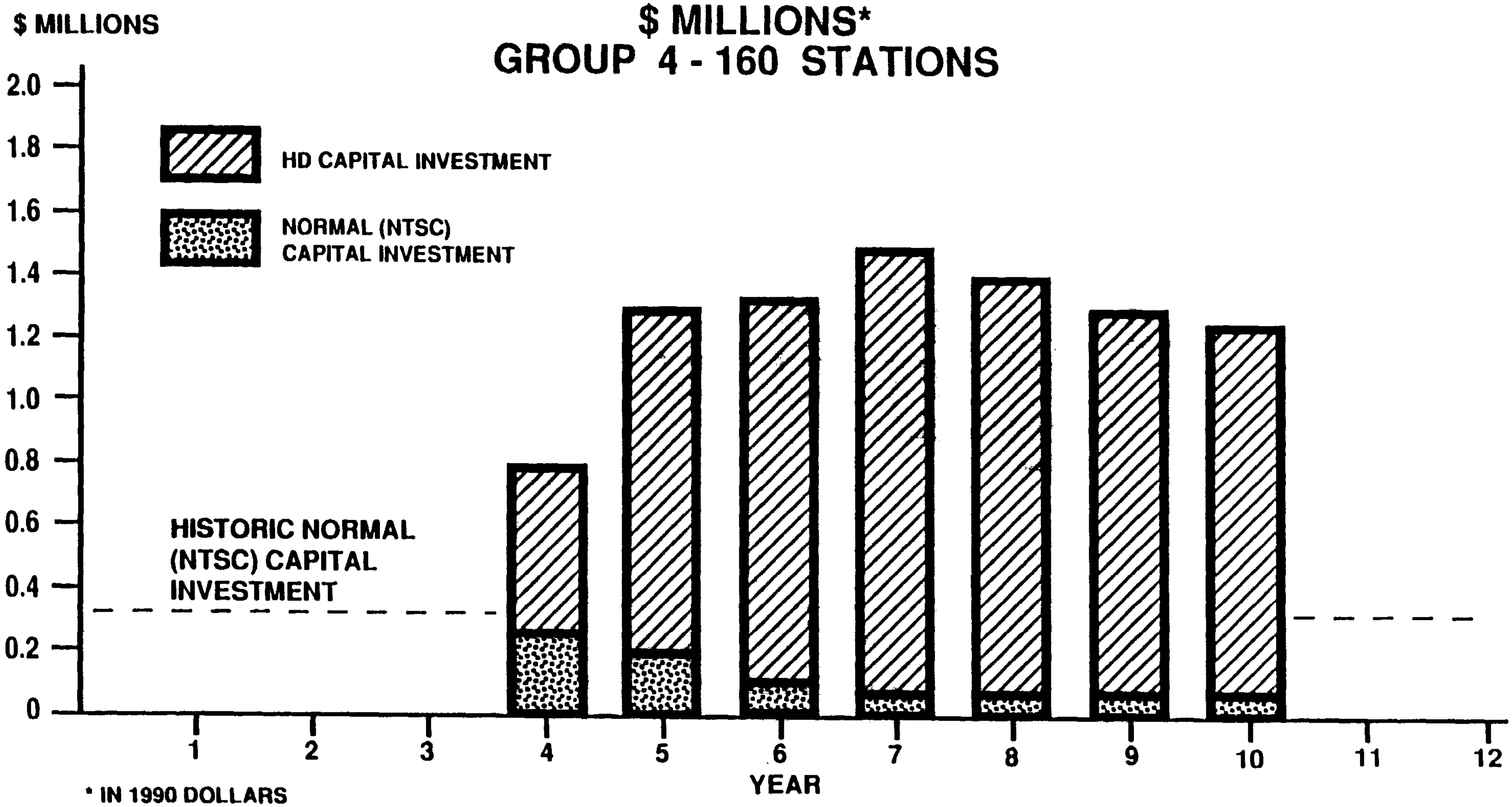
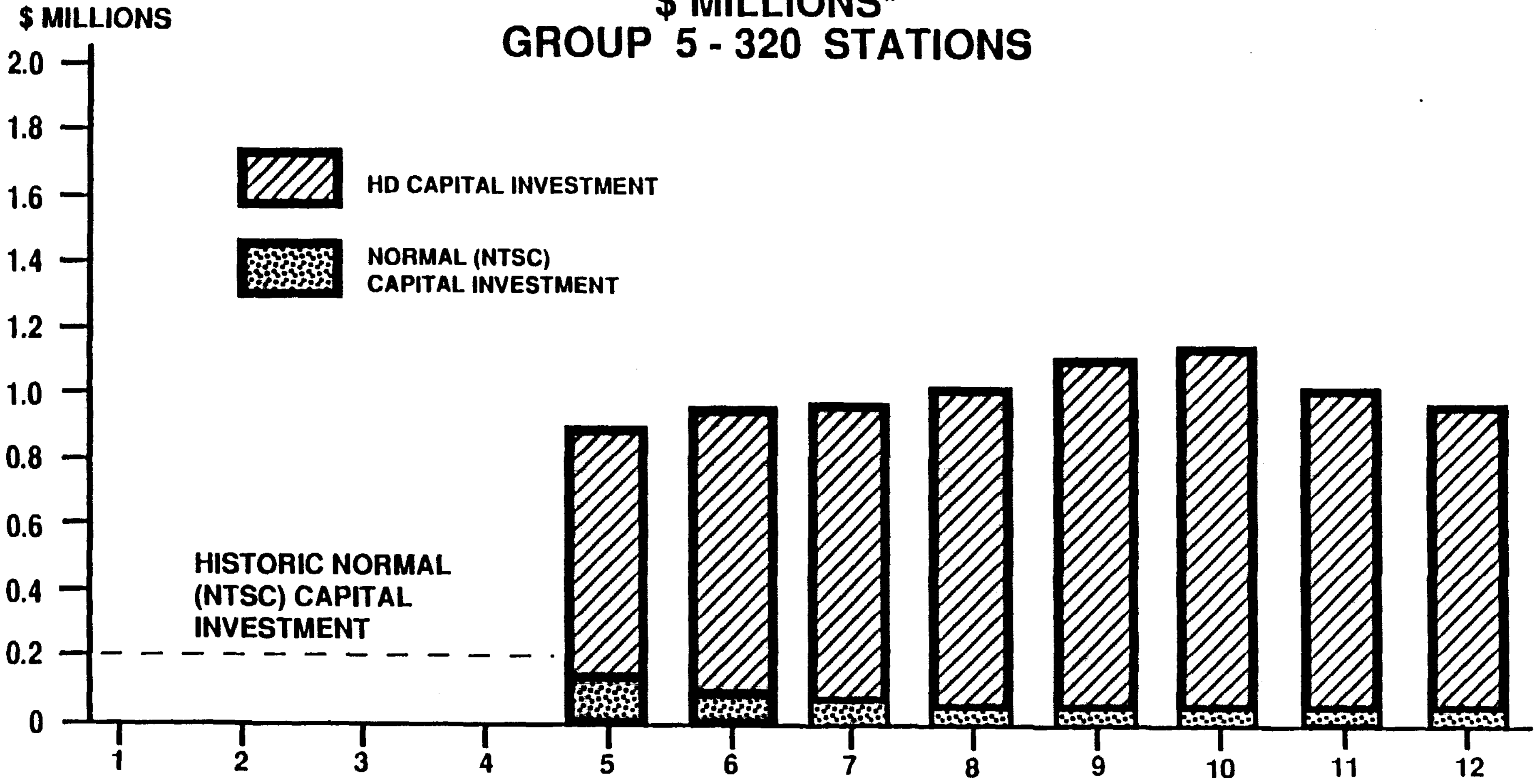


FIGURE 8

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT
$ MILLIONS*
GROUP 5 - 320 STATIONS



* IN 1990 DOLLARS

FIGURE 9

capital investment in NTSC equipment, which is assumed to be $1.0 million per year, or $5.0 million over the five-year conversion period. Thus the incremental cost of conversion, based on these assumptions, is 11.6 million less $5.0 million, or 6.6 million, plus the remaining cost (2.3 million) of maintaining some NTSC equipment during the conversion, shown in Figure 5. This analysis produces a total incremental cost of $8.9 million.

For the 40 stations in Group 2, the total capital investment in HD equipment is $10.4 million, (Fig. 4), and the historic level of capital investment in NTSC equipment is $0.5 million per year (Figure 6). The total net incremental cost for a station in this group is then $10.4 - (6 X 0.5) = $7.4 million, to which must be added the remaining NTSC equipment cost of $1.2 million, for a total of $8.6 million.

For the 320 stations in Group 5, whose total capital investment in HD equipment is $7.6 million, the net incremental cost of the transition is found to be $6.6 million. These projections are presented in Figure 10.

For all the 630 stations included in Groups 1-5, the average capital investment in HD equipment is $8.4 million per station, while the average total incremental cost over the assumed capital investment in maintaining and updating NTSC equipment is $6.3 million per station, to which must be added the remaining $0.8 million cost of maintaining some NTSC equipment during the transition, for a total net incremental cost of $7.1 million.

6.2. Capital Depreciation Charges

The impact of capital depreciation charges against revenues during the conversion period is significant. Assuming a 5-year straight line depreciation rate for HD equipment, the total depreciation charges for the

INCREMENTAL CAPITAL COST OF HDTV EQUIPMENT PER STATION

$ MILLIONS*

STATION GROUP	NO. OF STATIONS	HD EQUIPMENT CAPITAL INVESTMENT	HISTORIC NTSC CAPITAL INVESTMENT DURING TRANSITION PERIOD	REMAINING NTSC INVESTMENT DURING TRANSITION	NET INCREMENTAL CAPITAL COST
1	30	11.6	5.0	2.3	8.9
2	40	10.4	3.0	1.2	8.6
3	80	9.4	2.8	0.9	7.5
4	160	8.4	2.1	0.75	7.05
5	320	7.6	1.6	0.55	6.55

* IN 1990 DOLLARS

FIGURE 10

630 stations considered amount to $2,837 million, or an average total depreciation charge of $4.5 million per station. For tax purposes, this reduces the average total net cash flow for the acquisition of HD equipment to $3.9 million per station, considering only the period of conversion. Additional depreciation charges will, of course, be taken in the five years following the last year of the conversion program.

7. TRANSITION SCHEDULES

Each station is expected to implement its transition to HDTV over a period of several years, thus spreading the capital investment required over a period of from five to nine years, depending upon marketplace and competitive considerations.

The first stations to introduce HDTV service will probably be large stations in the top television markets. These are likely to be followed by stations in progressively smaller markets.

For example, the transition schedule may follow the pattern shown in Figure 11. Starting in Year 1, with the first group of 30 stations to convert, all of which serve the top ten television markets, the number of television households served, and the percentage of all TV households (TVHH), are presented.

Assuming this scenario, each group of stations will take several years to implement full conversion, with the first group of 30 stations taking 5 years, and the last Group 6 of 640 stations, many of whom will be in smaller markets, completing the conversion in 9 years. In this scenario, the timing of conversion for each group is shown in Figure 12.

HDTV TRANSITION SCHEDULE

START YEAR	GROUP NO.	STATIONS EQUIPPED	MARKET RANKINGS SERVED	TV HOUSEHOLDS SERVED (MILLIONS)	PERCENT TVHH SERVED
1	1	30	1-10	28	31
2	2	+40=70	1-30	48	53
3	3	+80=150	1-100	76	83
4	4	+160=310	1-150	84	95
5	5	+320=630	ALL	88	98
6	6	+640=1270	ALL	90	100

FIGURE 11

HD CONVERSION SCHEDULE BY PHASES FOR EACH GROUP OF STATIONS

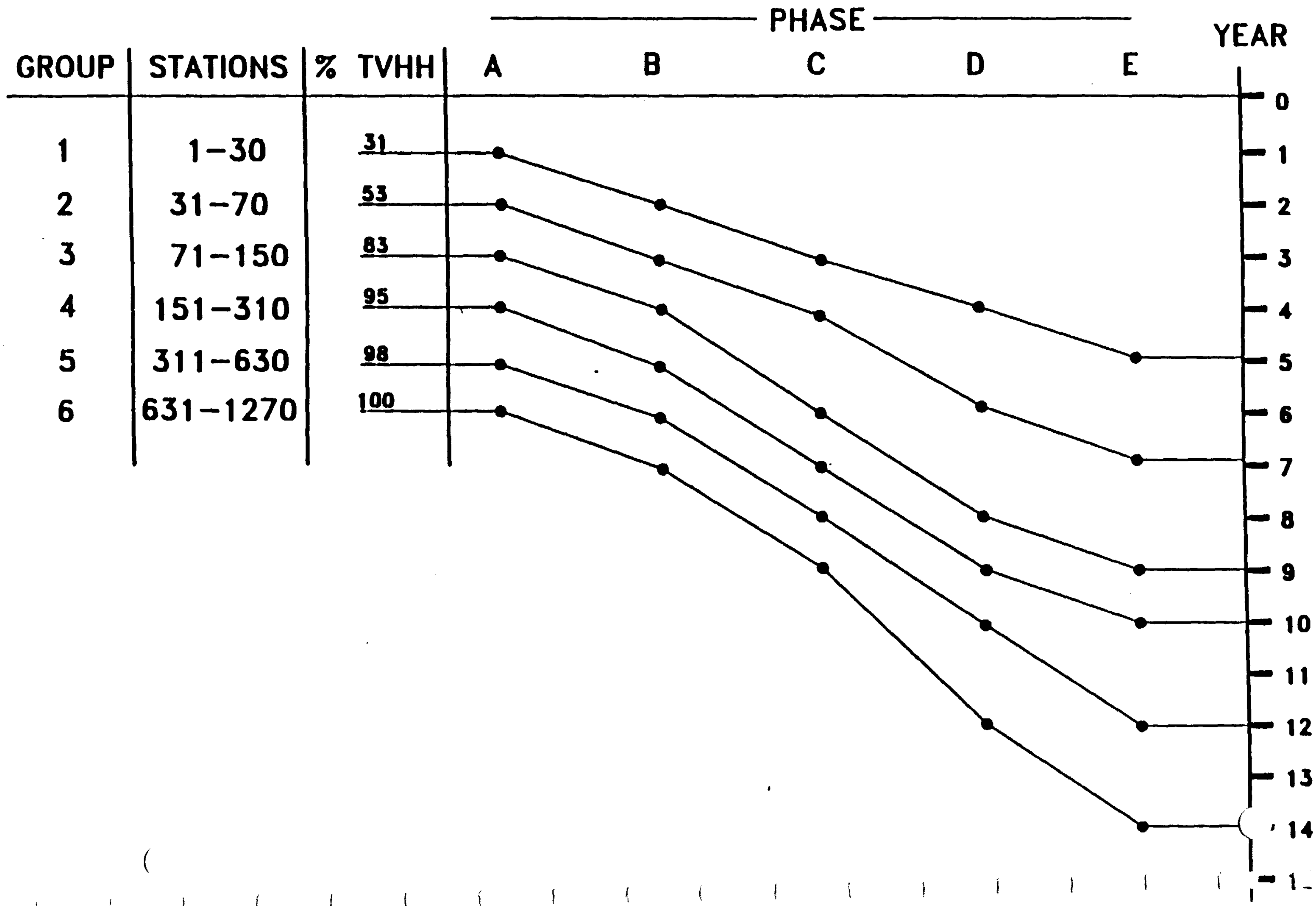


Figure 12 shows, for example, that when Group 2 has reached Phase D of the transition in the sixth year, 53% of television households will have HDTV service available, while in the eighth year, when the 160 stations in Group 3 have achieved Phase D, 83% or 76 million households will have HDTV service available.

The last Phase (F) of conversion to high definition electronic news gathering is not shown, because many stations may defer this phase for some years, as discussed previously.

8. CONCLUSIONS

At this point in the study, the following working premises are put forward for industry discussion.

(i) Phasing the transition to simulcast HDTV over several years is essential so that stations can time and pace their transition program based on their financial capacity and marketplace considerations. Such a transition scenario appears feasible.

(ii) The transmitter power for HDTV broadcast will be much less than for a NTSC transmitter, and the transmitting antenna will thus be smaller than its NTSC variant. New tower requirements for HDTV broadcast will therefore be minimal.

(iii) Equipment costs will decline significantly over the period of industry conversion to HDTV broadcasting.

(iv) The total capital investment required for transition to simulcast HDTV may range from $11.6 million for major market stations converting early to $7.6 million for small market stations converting later.

(v) The incremental capital investment required for the transition to simulcast HDTV may range from $9 million for major market stations to $7 million for small market stations.

These projections of capital cost are presented in Figure 13.

SIMULCAST HIGH DEFINITION TERRESTRIAL BROADCAST CAPITAL INVESTMENT REQUIRED
$ MILLIONS

	GROUPS OF STATIONS ACQUIRING EQUIPMENT				
GROUP	1	2	3	4	5
NO. OF STATIONS	30	+40=70	+80=150	+160=310	+320=630
% TVHH SERVED	31	53	83	95	98
A - TOTAL CAPITAL COST PER STATION	11.6	10.4	9.4	8.4	7.6
B - TOTAL INCREMENTAL COST OVER HISTORIC NORMAL NTSC CAPITAL COST	8.9	8.6	7.5	7.1	6.6

* IN 1990 DOLLARS

FIGURE 13

APPENDIX A

Towers for Simulcast Advanced Television Systems

The following is a memorandum submitted by Jules Cohen and Associates, PC., to Specialist Group 10 of the Planning Subcommittee's Working Party 3, dated June 19, 1990.

> "In estimates of the cost of initiating an Advanced Television System (ATV), a major item often included is a new tower. A survey of technical directors of television stations yielded the conclusion that, in the judgment of the technical directors, a substantial number of stations would require new towers to accommodate an additional antenna for ATV. For the reasons given below, new tower requirements are believed to have been exaggerated.
>
> The ATV system adopted for terrestrial transmission will have to be of such nature that it can be located at 100 to 120 miles from a co-channel NTSC broadcast station without causing interference to reception of the NTSC station to a degree any greater than co-channel NTSC stations now cause to each other when spaced in the order of 180 miles. Inherent in that requirement is the need for the ATV station to provide satisfactory service to a substantial area while using less effective radiated power (ERP) than the equivalent NTSC station. Lower ERP can mean not only smaller transmitters, but also smaller antennas and smaller diameter coaxial cable than its NTSC counterpart.
>
> Smaller antennas and cables reduce the weight required to be hung on a tower, but even more important, the smaller antennas and cables reduce the wind load. A tower not capable of carrying double its present load may very well be capable of accepting a lesser load without excessive derating.
>
> Prior to adding anything other than a trivial load to a tower, a stress analysis is necessary. Such analyses are likely to cost in the range of six to fifteen thousand dollars. Upon completion of the stress analysis, the tower owner is advised of what members, if any, in the tower would be over stressed if the new load is added. Substantial overloading of a large number of members will mean that the tower must be replaced. However, experience with similar situations indicates that the excessive stress is more often than not confined to a relatively small number of members.
>
> In the instance where the number of tower members needing attention is not excessive, the members can be replaced or reinforced. Sometimes the requirement is as simple as adding a second steel angle back-to-back with the steel angle already in place. Sometimes one or more guy levels must be supplied with larger diameter guys, or an additional group of guys provided at a new level, perhaps with other guys being repositioned.
>
> Strengthening an existing tower is much less costly than building a new tower. Even a fairly extensive amount of work can be accomplished within a one hundred thousand dollar budget. Furthermore, that work can usually be accomplished without disrupting the station operation.
>
> Quite obviously, all existing towers cannot be subjected to a stress analysis at this time to arrive at a more realistic cost figure for the ATV conversion. However, experience dictates a conclusion that relatively few stations would have to resort to tower replacement as a condition for adding a simulcast ATV channel."

APPENDIX C

ECONOMIC POTENTIAL OF ADVANCED TELEVISION PRODUCTS

Report by
Larry F. Darby
Darby Associates
for
National Telecommunications and
Information Administration

7 April 1988

EXECUTIVE SUMMARY

The television receiver has been one of the few constants in American life in the post-war period. To be sure, citizens have enjoyed the transition from monochrome to color pictures, the addition of alternative program and signal sources, and the option to alter program schedules through recording devices. But the "box"? Some bigger; some smaller; some thinner; some with remote control, stereo sound or a hint of intelligence variously applied. All in all, not much change.

This remarkable stability is about to yield, however, to the forces of digital technologies and market economics which have literally revolutionized so many other aspects of US industry, commerce and consumer welfare.

Research and development groups in several countries have been working for several years to devise and test systems and equipment embodying state-of-the-art integrated circuit technologies to be used in the production, distribution and display of dramatically improved television picture and sound quality. The results to date are impressive. Theater quality images and sound are obtainable from television receivers utilizing these new technologies. Receiver prototypes have been demonstrated under real world conditions and production models are scheduled to be made available to US consumers in the next two to three years.

This paper reports the results of an exploration of the market and public policy implications of the imminent introduction of a range of products which incorporate advanced television (ATV) technologies. The major purpose has been to identify and, where possible, indicate the potential magnitude of the principal economic impacts of the technology. After reviewing market histories of electronics products generally and selected consumer electronic products more intensively, the paper constructs two ATV consumer product growth scenarios. These scenarios characterize potential ATV consumer product diffusion, driven first by a set of pessimistic assumptions about consumer preferences and the economic environment and, secondly, by more optimistic assumptions which result in ATV product diffusion that more or less mirrors the growth paths of successful new consumer electronics products in the United States.

If the growth path of ATV receivers and VCRs traces the historical sales tracks of conventional color television receivers, videocassette recorders, home computers and television receive-only antennas, the new products will achieve one percent household penetration about ten years from now. Applying subsequent growth rates representative of those achieved by their predecessors indicates that household penetration of the new products may reach 25% in about fifteen years and in twenty years may exceed 70% household penetration. Valuing these unit sales using high and low pricing scenarios yields cumulative market valuation ranges ten, fifteen and twenty years out of $1.7 to $3.5 billion, $26 to $52 billion, and $72 to $144 billion.

Any product market valuation is sensitive to several economic and other forces which may or may not materialize in the next twenty years. Rather than attempting to forecast those forces, the analysis attempts to identify them and to indicate clearly the nature of the sensitivity to them of the calculated scenario values. The algorithm of the calculated scenarios is detailed so that different values, based on different assumptions, can be readily calculated.

Based on the scenario values of primary ATV market development, the analysis explores selected other secondary or indirect economic and market impacts induced by US household adoption of ATV products. Drawing on the results of previous studies of the economic role of electronics industries in the domestic economy, the analysis identifies potential multiplier effects on national income, employment, the balance of trade and the Federal budget.

The total effect on national income of ATV product penetration is the sum of direct and induced economic effects. The scenarios indicate the potential direct economic effects, but "multiplier" effects rippling throughout the economy may yield total economic activity two to three times the level suggested by the scenarios. Utilizing a previously estimated average for value-added per worker in the electronic industries suggests that over 100,000 US jobs may be at stake by the turn of the century.

The scenarios for potential diffusion of ATV related products also implicate immense potential impacts on both the balance of trade and the federal budget. Substantial participation by US manufacturers in the ATV product market may lead to significant contributions toward restoring balance in the twin deficits.

Based on a review of major studies of the causes and consequences of the decline of US leadership in electronics industries generally, and semiconductors more specifically, the paper concludes that imminent developments in markets for ATV products will create both enormous opportunity and risk for US firms and the national interest. Consequently, government policies influencing private sector incentives in developing these technologies are ripe for comprehensive review for consistency with the long term national interest.

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